Columbia and Snake Mainstem Temperature Assessment, TMDL, and Potential Actions by Dams

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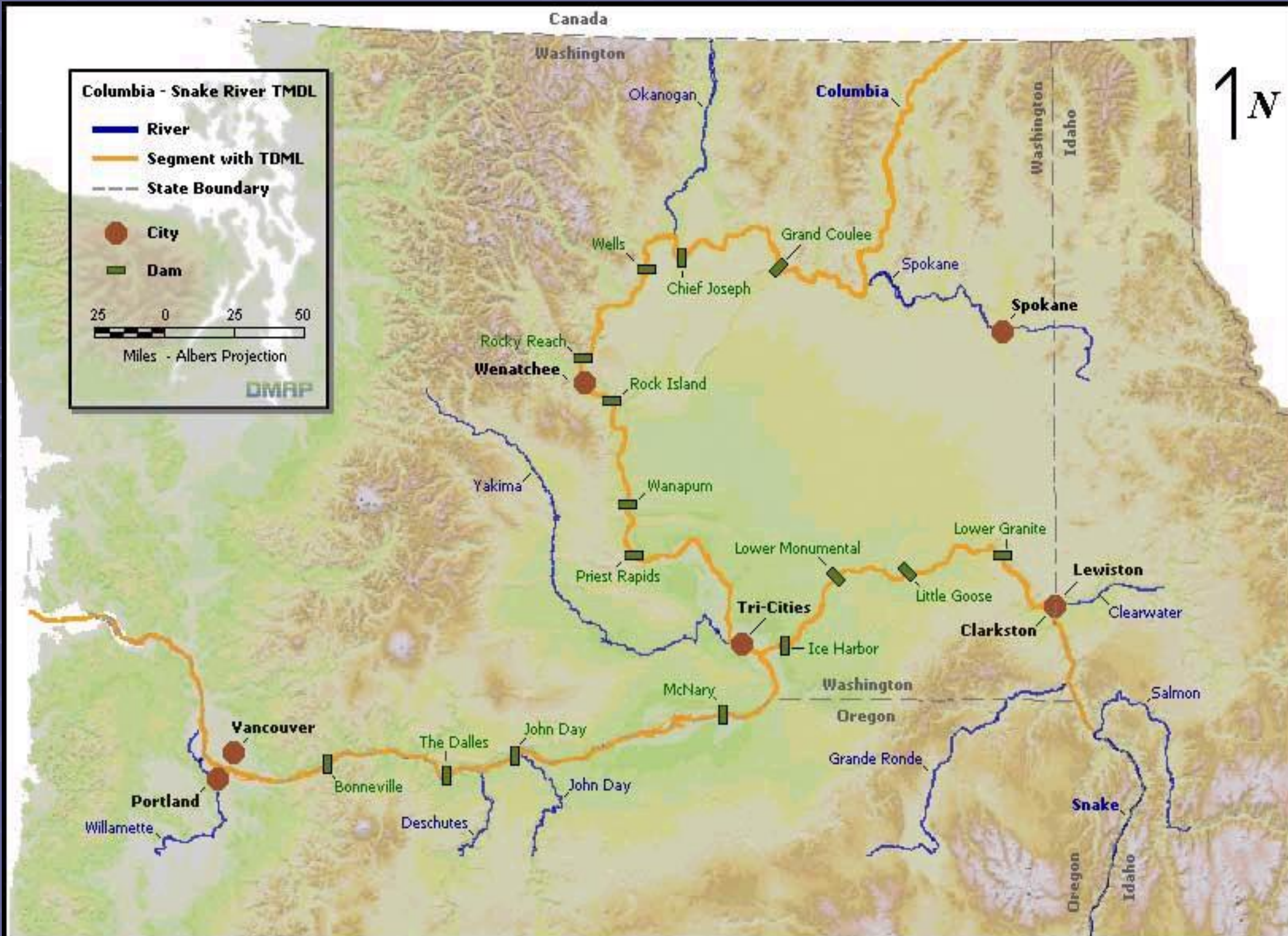
Outline

- Past Assessments and Draft TMDL
  - RBM10 Model
  - Assessment and Draft TMDL
  - Implementation Options for Dams
- General Path Forward
- Simplification

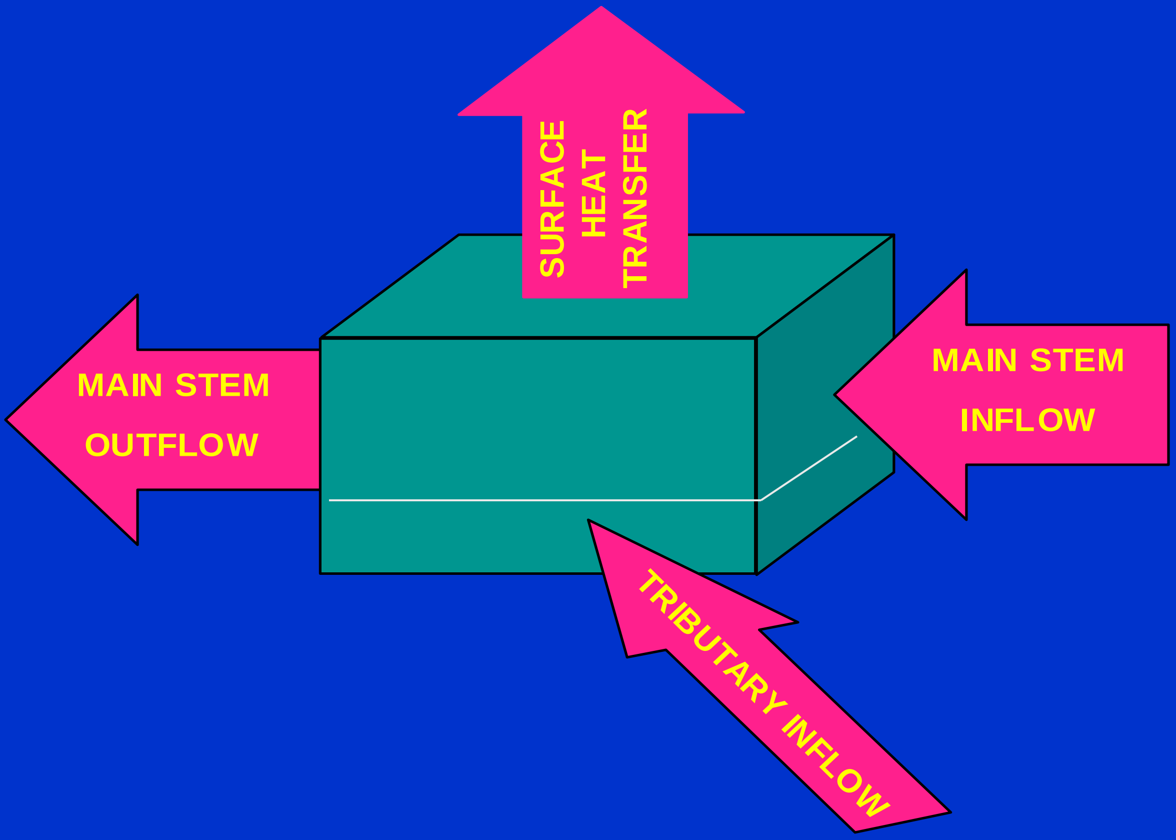
RBM 10 Model

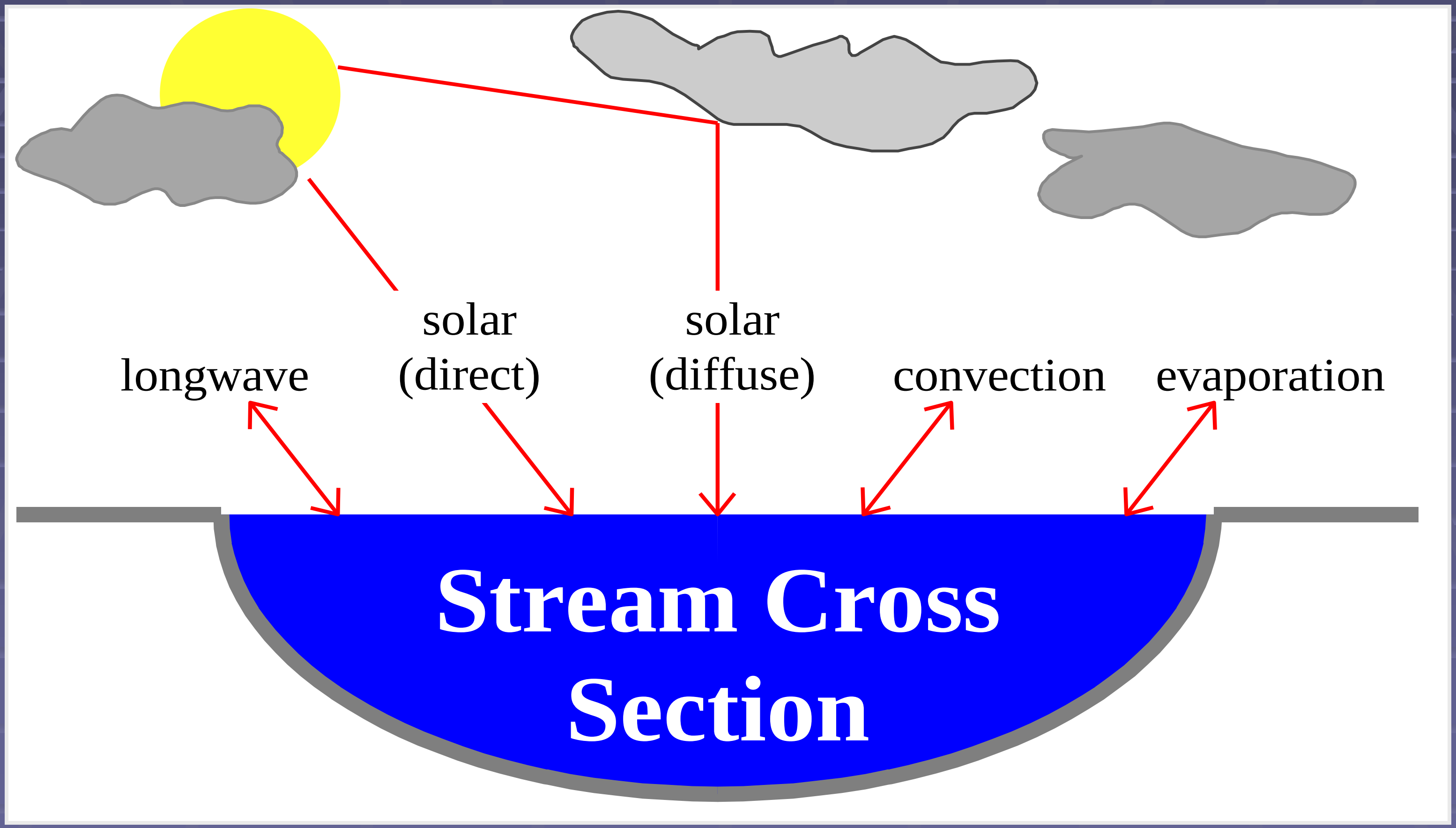
RBM10

- Developed by EPA Region 10 (Yearsley)
- 1D, Dynamic Temperature Model
  - estimates cross-sectional avg temperature
  - Model segments are approx. 1 mile long
- Peer Reviewed
- Used by Columbia River Tech Management Team (TMT) for Dworshak Planning for several years


Canada
Washington
Columbia - Snake River TMDL
River
Segment with TDML
State Boundary
City
Dam
25 0 25 50
Miles - Albers Projection
DMAP
Okanogan
Columbia
Washington
Idaho
N
Wells
Chief Joseph
Grand Coulee
Spokane
Spokane
Rocky Reach
Wenatchee
Rock Island
Yakima
Wanapum
Priest Rapids
Lower Monumental
Lower Granite
Little Goose
Lewiston
Clearwater
Clarkston
Tri-Cities
Ice Harbor
Washington
Oregon
McNary
Salmon
Vancouver
The Dalles
John Day
Bonneville
John Day
Grande Ronde
Portland
Willamette
Deschutes
Snake
Oregon
Idaho

ONE-DIMENSIONAL ENERGY BUDGET MODEL





solar
(direct)
solar
(diffuse)
longwave
convection
evaporation
Stream Cross
Section

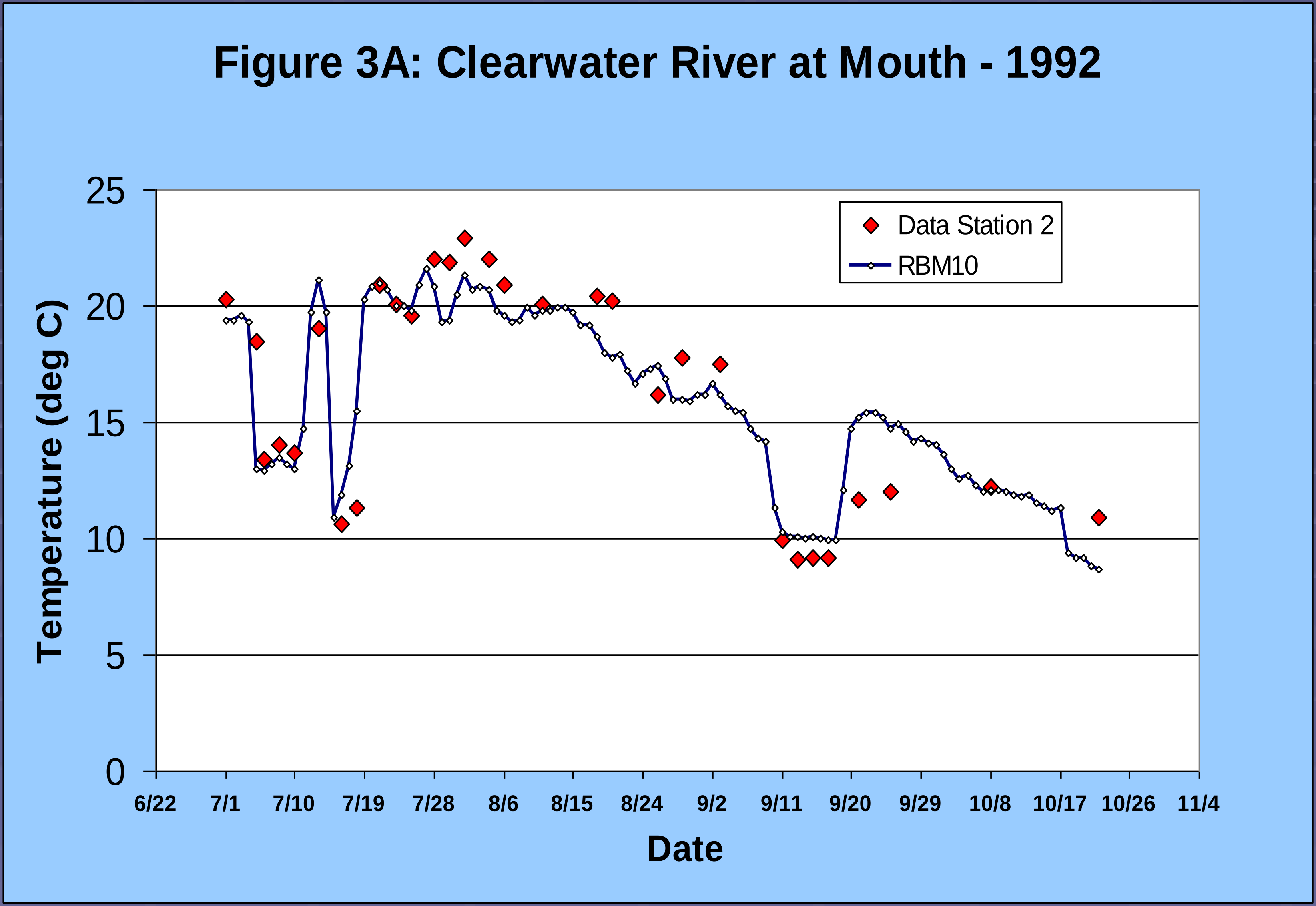
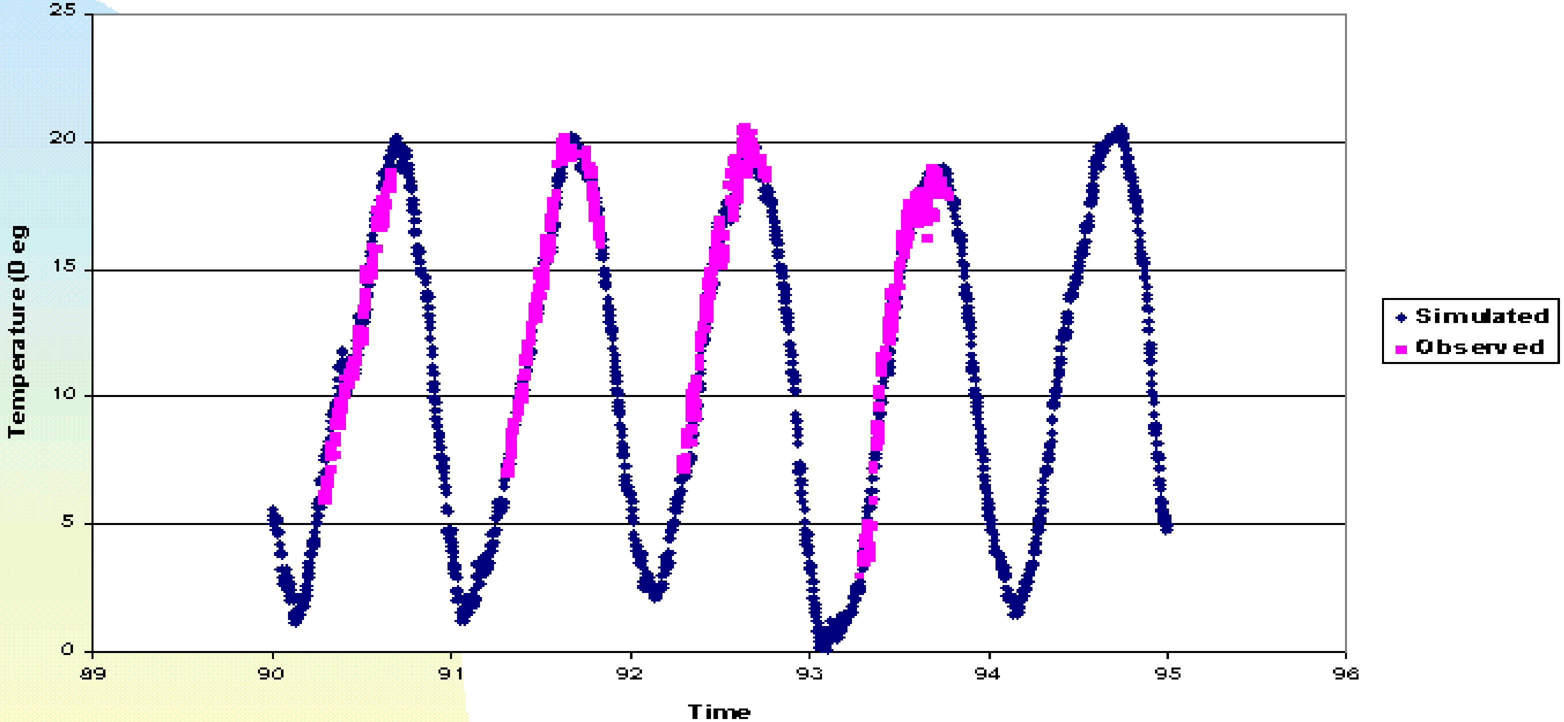
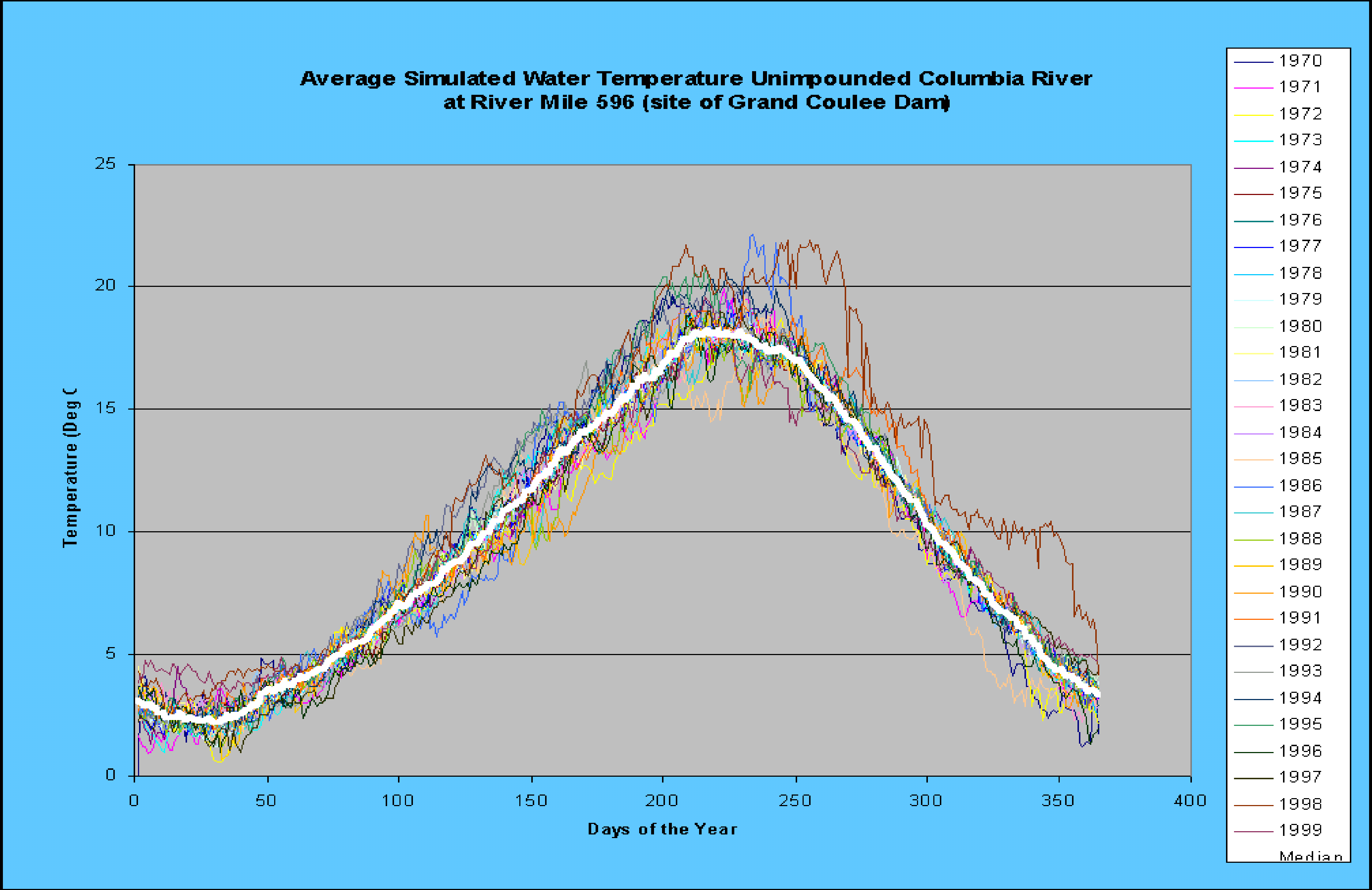


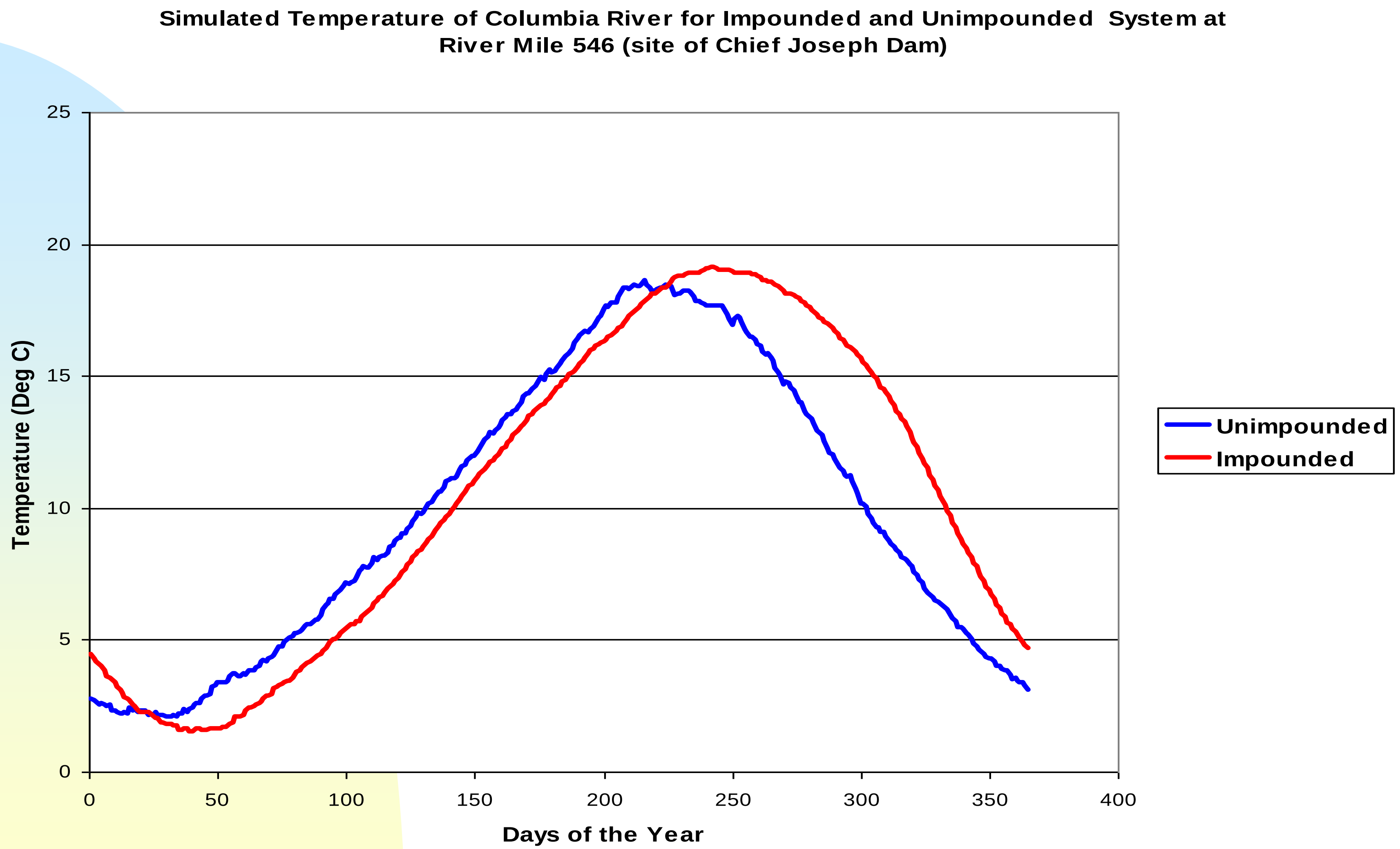
Figure 3A: Clearwater River at Mouth - 1992
Data Station 2
RBM10
Temperature (deg C)
25
20
15
10
5
0
6/22
7/1
7/10
7/19
7/28
8/6
8/15
8/24
9/2
9/11
9/20
9/29
10/8
10/17
10/26
11/4
Date

Simulated and Observed Temperatures at Grand Coulee 1990-1994





Average Simulated Water Temperature Unimpounded Columbia River
at River Mile 596 (site of Grand Coulee Dam)
Temperature (Deg C
Days of the Year
0
5
10
15
20
25
0
50
100
150
200
250
300
350
400
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
Median



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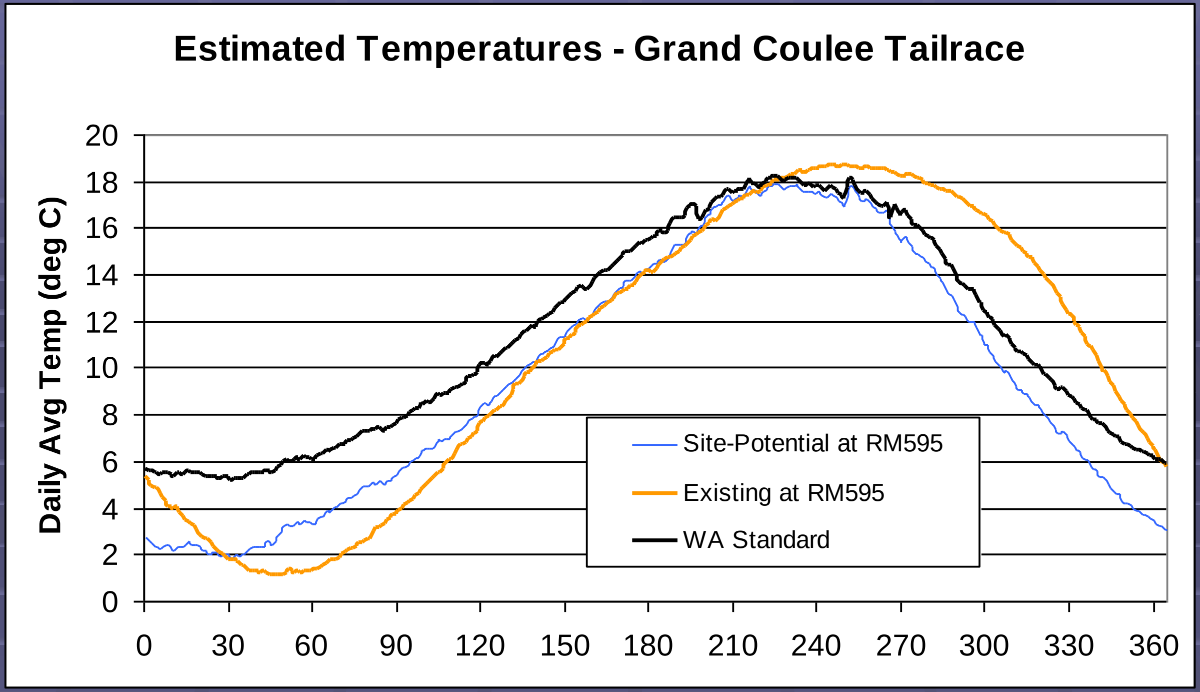
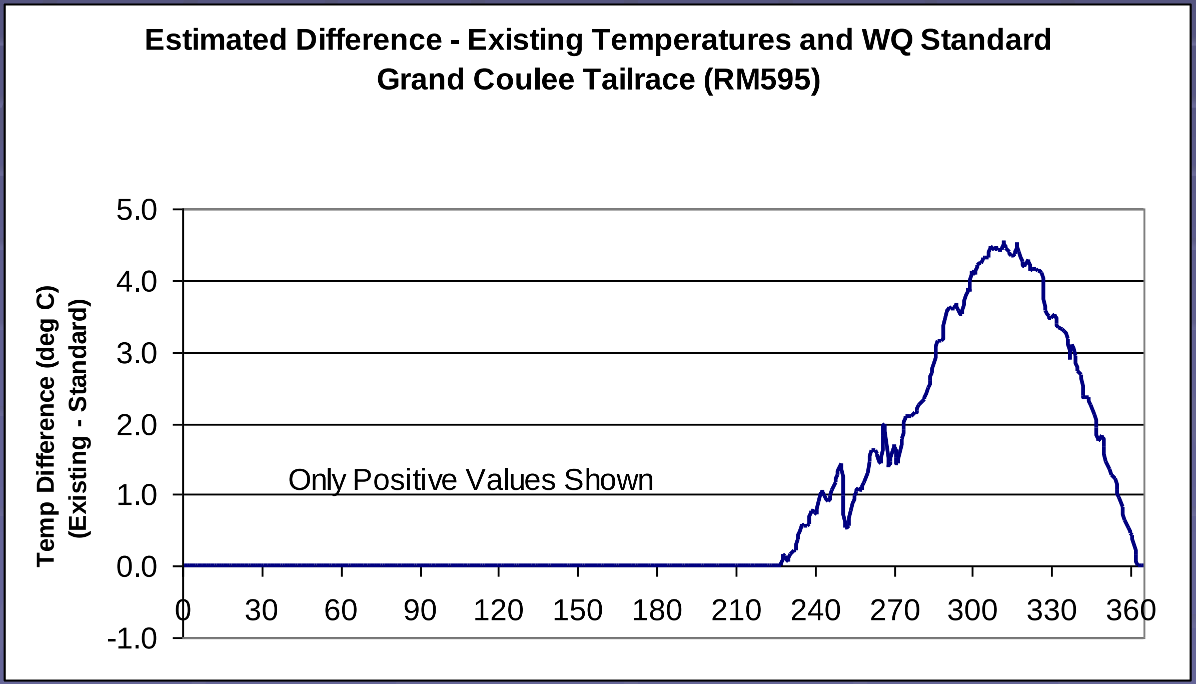
Assessment and TMDL

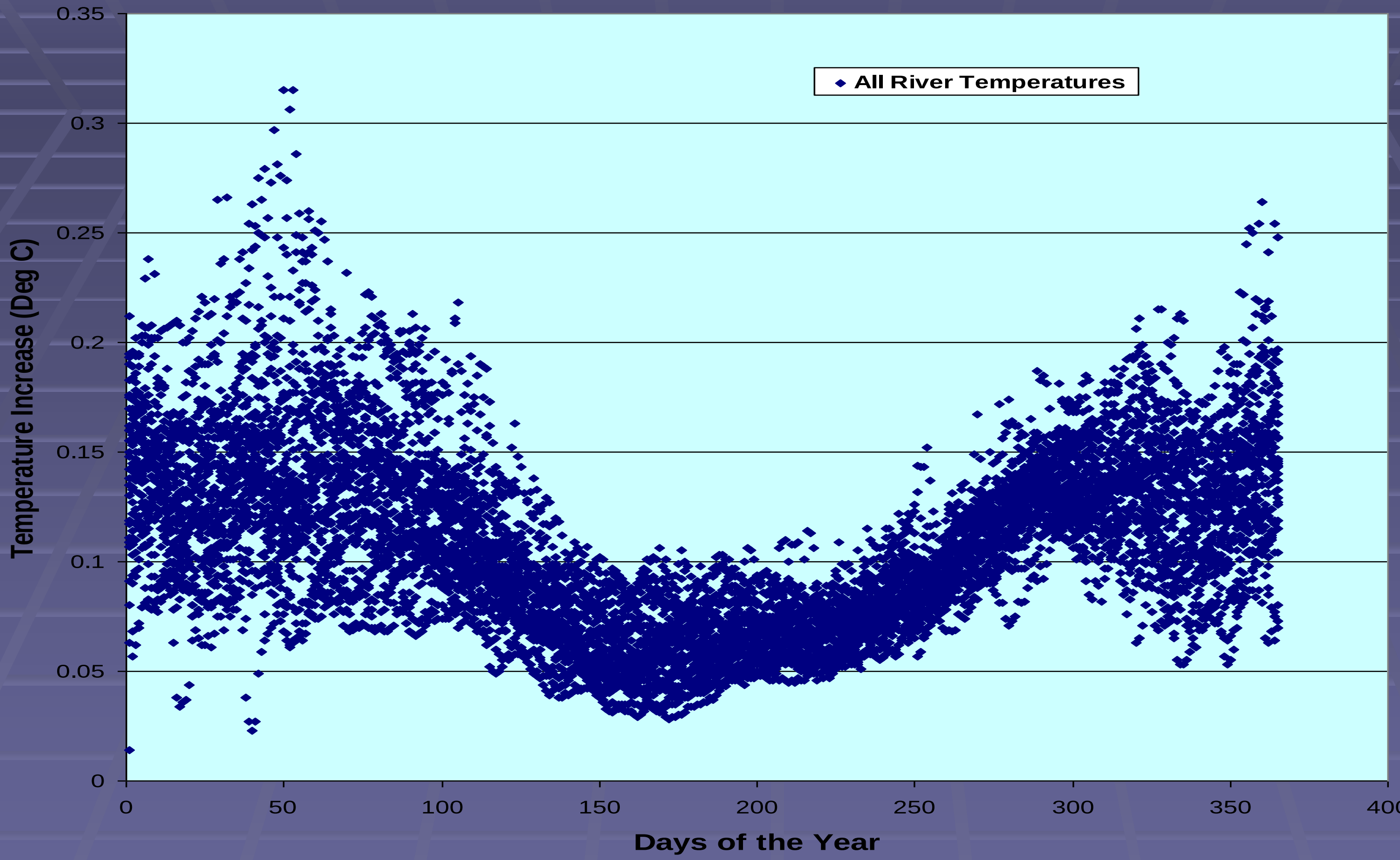

Estimated Temperatures - Grand Coulee Tailrace
Daily Avg Temp (deg C)
20
18
16
14
12
10
8
6
4
2
0
0
30
60
90
120
150
180
210
240
270
300
330
360
Site-Potential at RM595
Existing at RM595
WA Standard


Estimated Difference - Existing Temperatures and WQ Standard
Grand Coulee Tailrace (RM595)
Temp Difference (deg C)
(Existing - Standard)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
Only Positive Values Shown
0
30
60
90
120
150
180
210
240
270
300
330
360

Tributaries

Tributary	Average Flow (CFS)	Columbia Average Flow (CFS)	✦T (°C) to raise Columbia Temperature	
			0.5 °C	**0.14°C**
Spokane River	7,812	~ 100,000	7.0	1.9
Okanagan River	3,145	~106,255	17.0	4.9
Yakima River	3,569	~118,400	17.0	4.8
Snake River	55,090	~118,400	1.6	0.44
Deschutes	5,839	~185,161	16.0	4.6
Willamette	34,205	~191,000	3.2	0.92
		Snake Average Flow (CFS)	**✦T (°C) to raise Snake Temperature**	
			0.5 °C	**0.14°C**
Salmon	11240	~23560	1.5	0.43
Grande Ronde	3101	~34800	6.0	1.7
Clearwater	15430	~37901	1.5	0.48

Impact of Point Sources on Mainstem Temperatures



Simulated Increases in Temperature at River Mile 42 in the Columbia River due to the Existing Point Sources

Assessment Conclusions

(from model reports, Problem Assessment, etc.)

- Dams – cause temperature shift that exceeds standards
  - Grand Coulee, Lower Snake Dams, John Day - biggest impact
- Tributaries - minor effect on the mainstem temperature
  - Exceptions
    - Snake effect on Columbia
    - Salmon and Clearwater effect on Snake
- Point sources < 0.3 deg C cumulative impact
- Climate change – may account for slight warming

TMDL

- WQ Standards Patchwork
  - Variable criteria, allowable increases abv natural condition, & criteria timeframes by location

Table S-1: Summary of Water Quality Standards that Apply to the Columbia and Snake Rivers

Columbia River Reach	Criterion	Natural Temp < Criterion	Natural Temp > Criterion
Canadian Border to Grand Coulee Dam	16 °C DM	Natural + 23/(T+5)	Natural + 0.3 °C
Grand Coulee Dam to Chief Joseph Dam	16 °C DM	Natural + 23/(T+5)	Natural + 0.3 °C
Chief Joseph Dam to Priest Rapids Dam	18 °C DM	Natural + 28/(T+7)	Natural + 0.3 °C
Priest Rapids Dam to Oregon Border	20 °C DM	Natural + 34/(T+9)	Natural + 0.3 °C
Oregon Border to mouth	12.8/20 °C DM	Natural + 1.1 °C	Natural + 0.14°C
Snake River Reach	**Criterion**	**Natural Temp < Criterion**	**Natural Temp > Criterion**
Salmon River to OR/WA Border	12.8/17.8 °C 7DADM	Up to Criterion	Natural + 0.14 °C
OR/WA Border to ID/WA Border	20 °C DM	Natural + 1.1 °C	Natural + 0.3 °C
ID/WA Border to Mouth	20 °C DM	Natural + 34/(T+9)	Natural + 0.3 °C

T = the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.
DM = daily maximum temperature.
7DADM = seven day average of the daily maximum temperatures.

TMDL

- 21 Target Sites
  - 15 sites at dam tailraces
  - 5 sites below Bonneville Dam
  - 1 site at Lewiston

Natural Conditions

- Dealing with a portion of the Columbia Basin
  - We assume current temperatures and inflows at boundaries to mainstem rivers
    - Snake River at Brownlee tailrace
    - No Dworshak temp control or flow augmentation
    - Columbia River at Canadian border
    - All tributaries at existing conditions
  - “Site Potential” Temperature
    - estimated temperature within the project area in the absence of sources in the project area.

TMDL

- Sources with allocations
  - 15 Dams
  - 244 Point Sources
    - 11 Large individual permits w/individual allocations
    - 97 Smaller individual permits w/group allocations
    - 136 General permittees w/group allocations
  - 20 Tributaries

- Sources considered minimal
  - Shade, hyporheic alteration, climate change
  - Small tributaries not included in the model

Critical Location

- Critical Location
  - River Mile 42
  - Cumulative impacts of all upstream dams, point sources
  - Standard – allowable changes to nat’l condition
    - < 0.3 deg C change in summer
    - <1.1 deg C change in late fall/winter

Seasonality

- July 1 – October 31
- Nov 1 – Feb 5

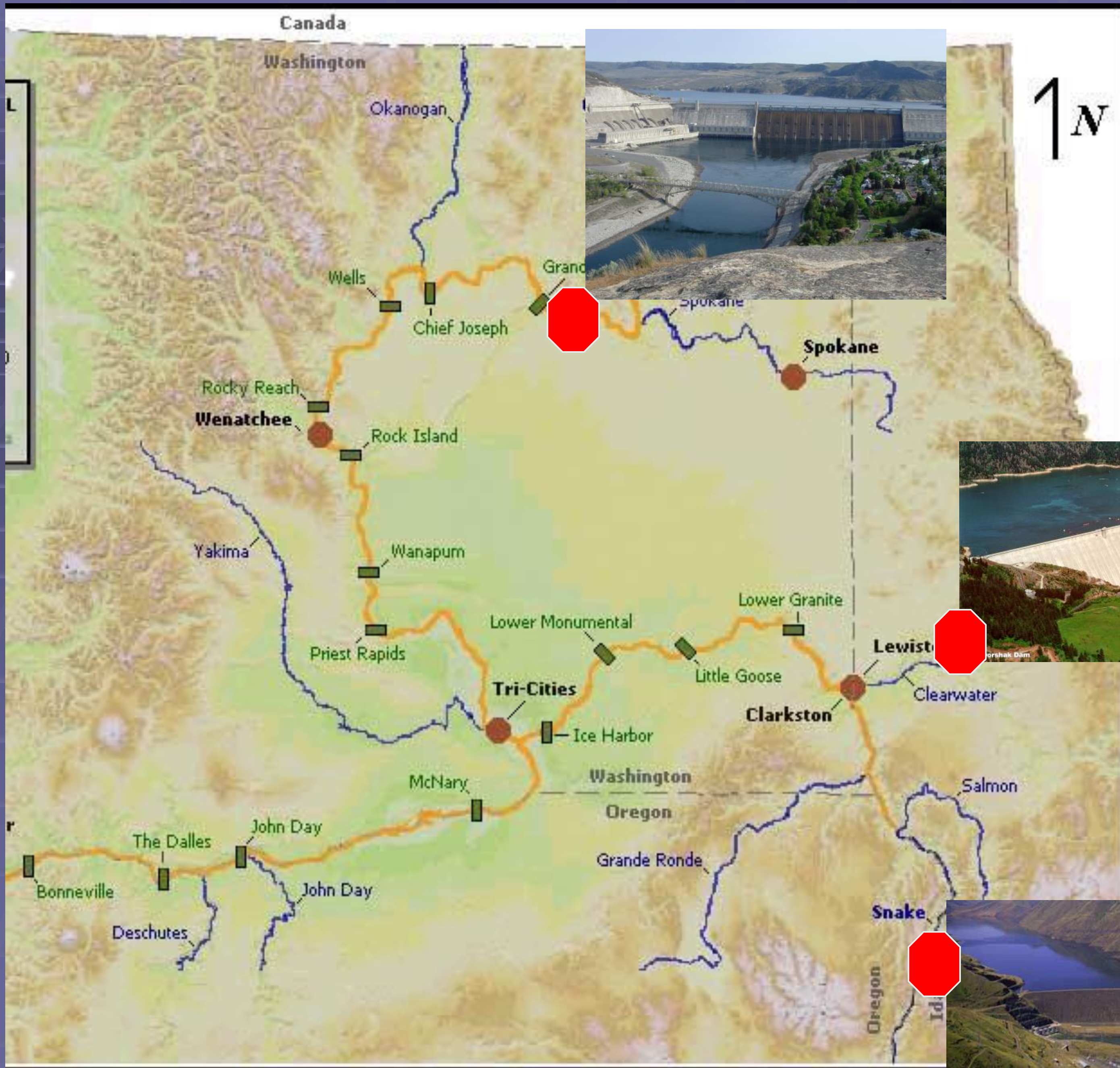
- Existing temperatures do not exceed site potential temperatures from Feb 6-July 1.

- Most stringent standard changes on Nov 1

Bottom Line

- Point Sources allocated existing loads
- Tributaries allocated existing loads
- Dams
  - 5 smallest impact dams allocated existing impact (Wells, Rocky Reach, Rock Island, Priest Rapids, The Dalles)
  - Remaining dams allocated near-zero increases to natural conditions

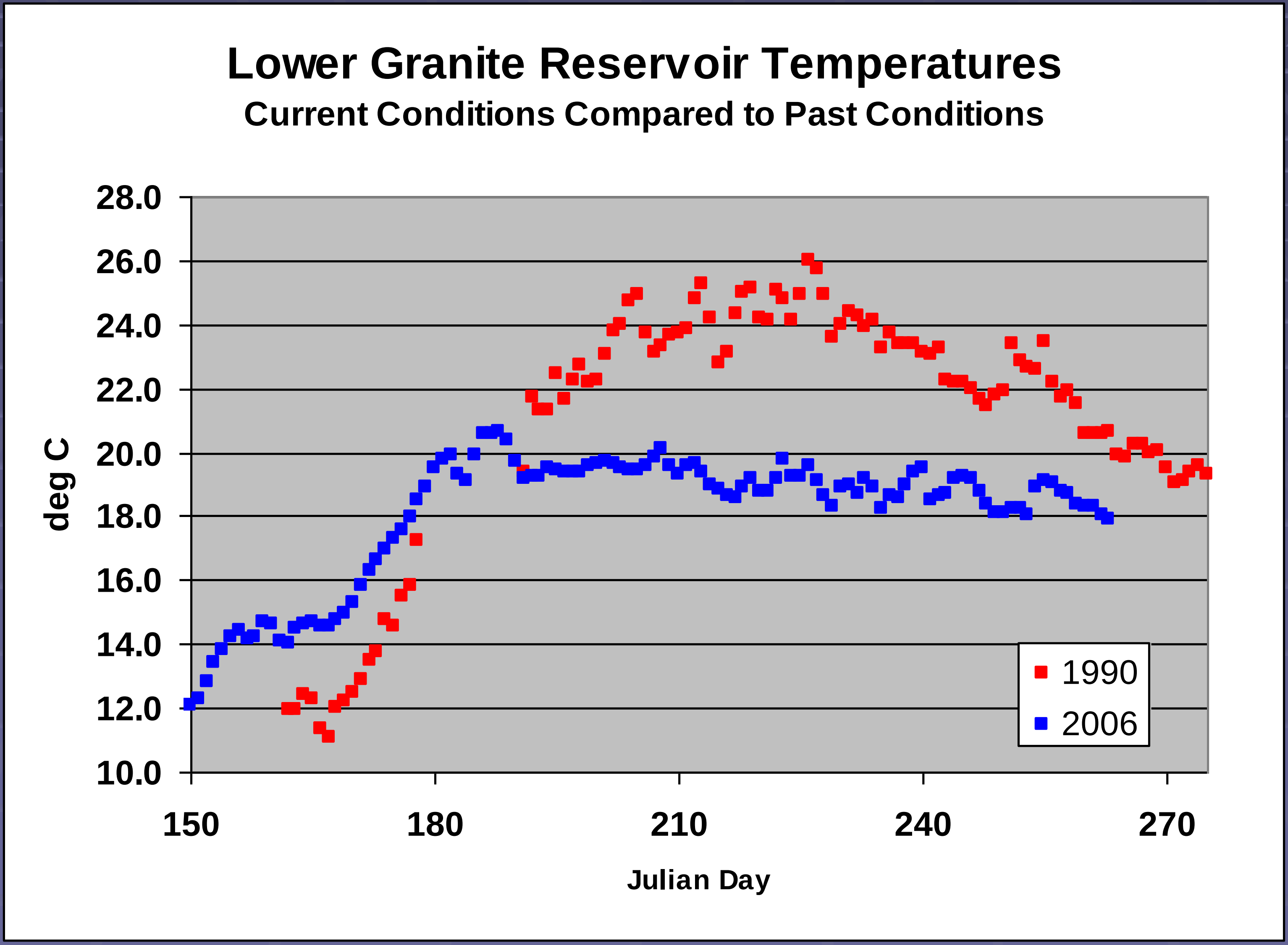
Implementation Options for Dams


Canada
Washington
Okanogan
Wells
Chief Joseph
Grand
Spokane
Spokane
Rocky Reach
Wenatchee
Rock Island
Yakima
Wanapum
Priest Rapids
Lower Monumental
Lower Granite
Little Goose
Lewist
Clearwater
Tri-Cities
Clarkston
Ice Harbor
Washington
Oregon
McNary
Salmon
John Day
The Dalles
John Day
Bonneville
Deschutes
Grande Ronde
Snake
Oregon
N

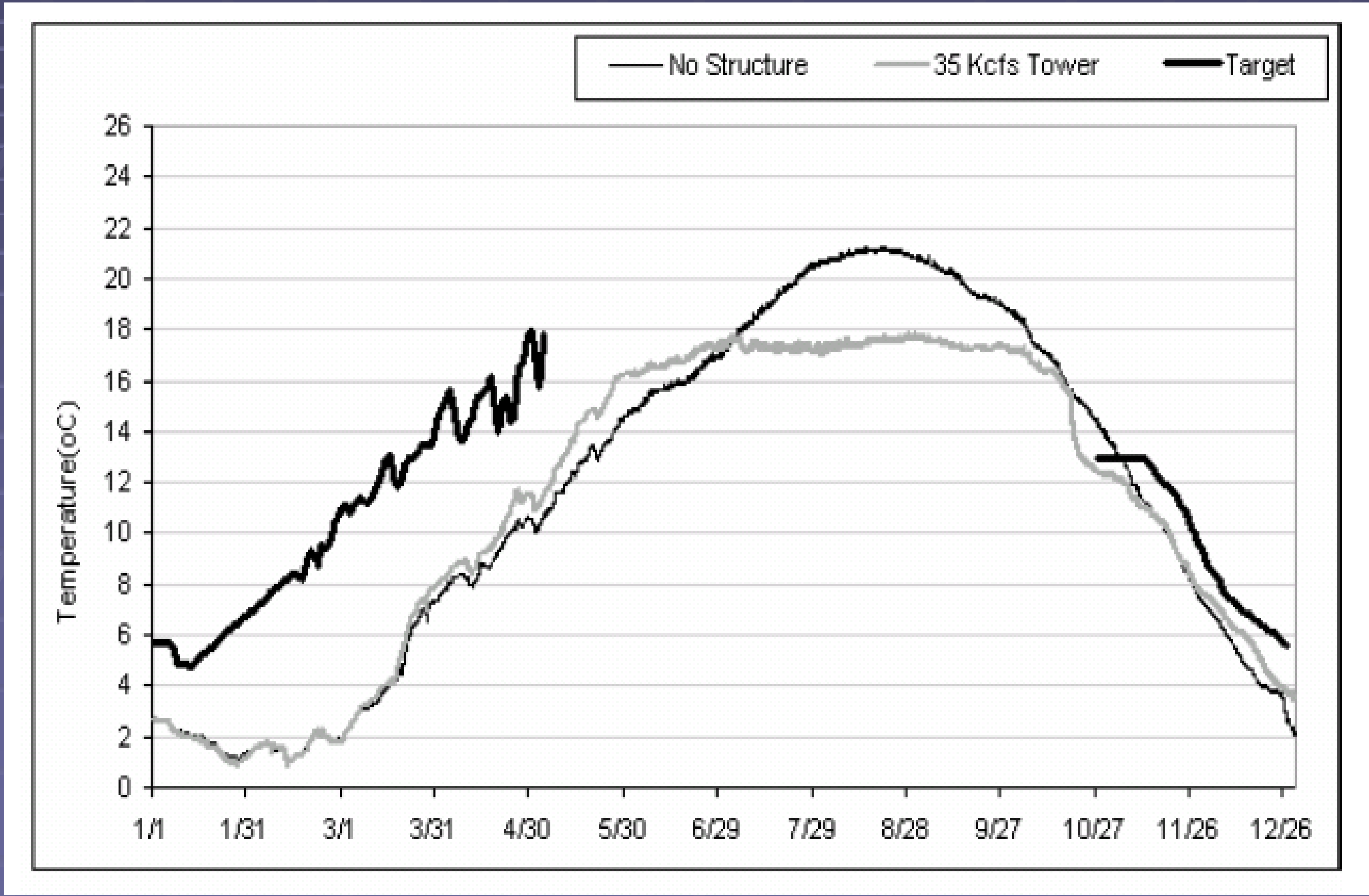

Potential Changes in Dam Operations

- Selective Withdrawal
  - Dworshak – full gate structure in operation
  - Brownlee – no structure, EPA pushing for one
  - Gr. Coulee – no structure, potential switch in powerhouse usage
- Flow Augmentation
  - Dworshak – current large summer augmentation
  - Brownlee – current modest summer augmentation
  - Gr. Coulee – no augmentation
- Local Dam Design and Operations
  - ladders, forebay bubblers, Grand Coulee Columbia project withdrawal depth

Dworshak Operations



Brownlee Potential Operations



Grand Coulee Potential Operations

- Selective withdrawal very expensive
  - benefit probably modest (modest stratification)
- Powerhouses draw from different depths
  - Switch flow from Powerhouse 3 to 1 & 2
  - Notably colder expected releases (1-2 deg C)
- No reservoir model of Grand Coulee
  - hampers analysis of management options
  - example – change to Banks Lake withdrawal depth?
  - example – alternative flood control operations?

Path Forward

Strawman

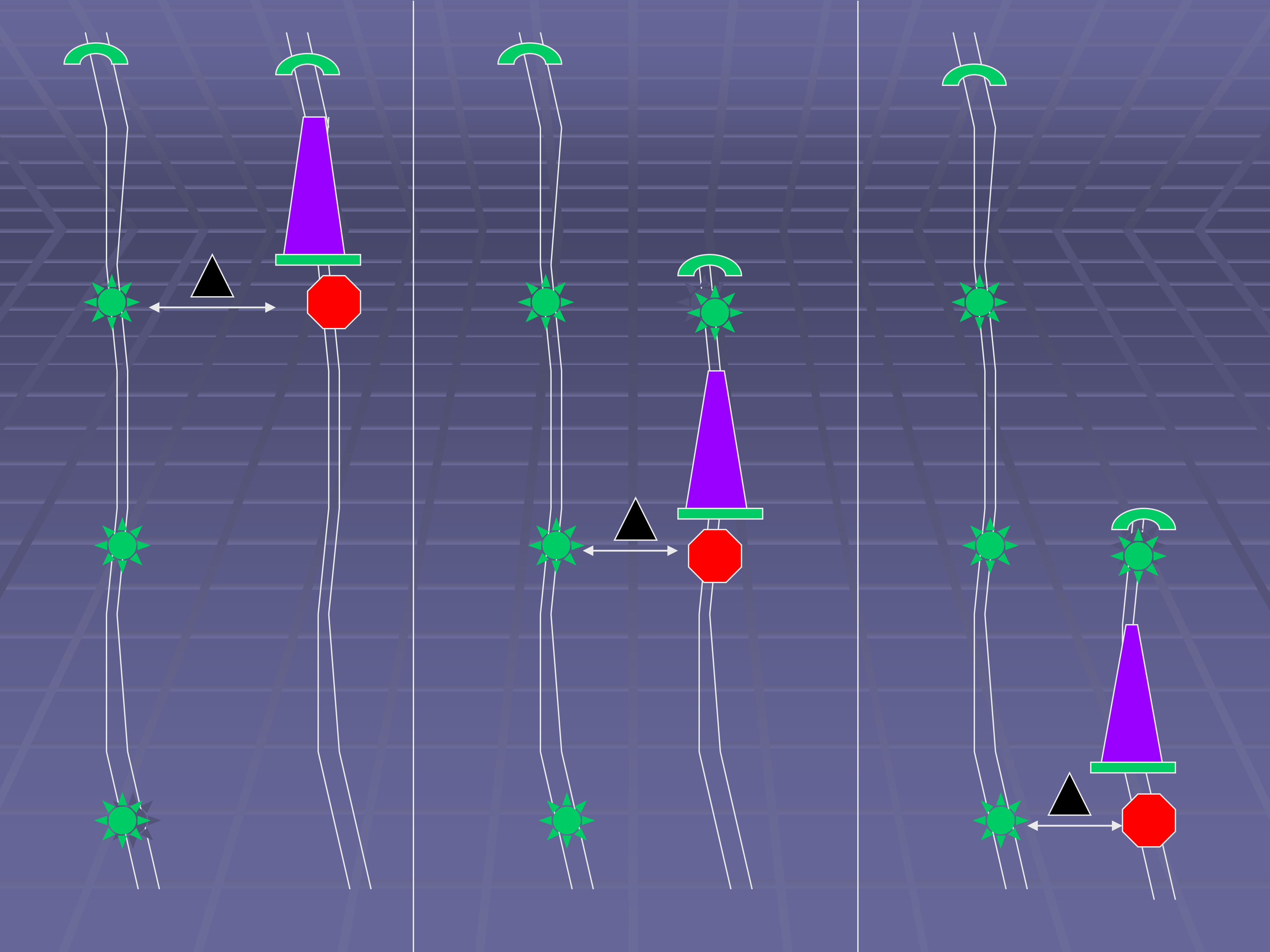
- Identify/Resolve Outstanding Policy Issues
- Model Review Meeting
- Quantify Improvement Needed to Meet WQS
  - Based on 1970-2000 model simulations (no update)
  - Develop basic TMDL info (more below)
- Corps/Bureau Lead Implementation Analysis
- Start Joint TMDL and UAA Product

Simplification

Draft TMDL Difficulties

- Allocating to individual dams
- Simulating the TMDL compliance scenario
- Determining if small dams are OK

- High modeling cost and complexity
  - Hundreds of model runs - 21 TMDL scenarios
  - Lots of data to handle - 30 years, daily values
  - Conundrums building the compliant scenario
    - assume free-flowing river and add impact or assume impounded river and subtract impact?
    - put the dam into nat'l river or take it out of impounded river to estimate its impact?
    - put point sources into nat'l river or impounded river to estimate impact?



Individualizing

-adds a model configuration for each dam

- Temp reduction (delta) assigned to individual dam assumes upstream achieves standard

– we do not list "current condition" since it is not relevant to individual allocations

- questionable practical use of the individual reduction values (e.g., "Reduction from what?")

Load Allocations for **Dam 1**

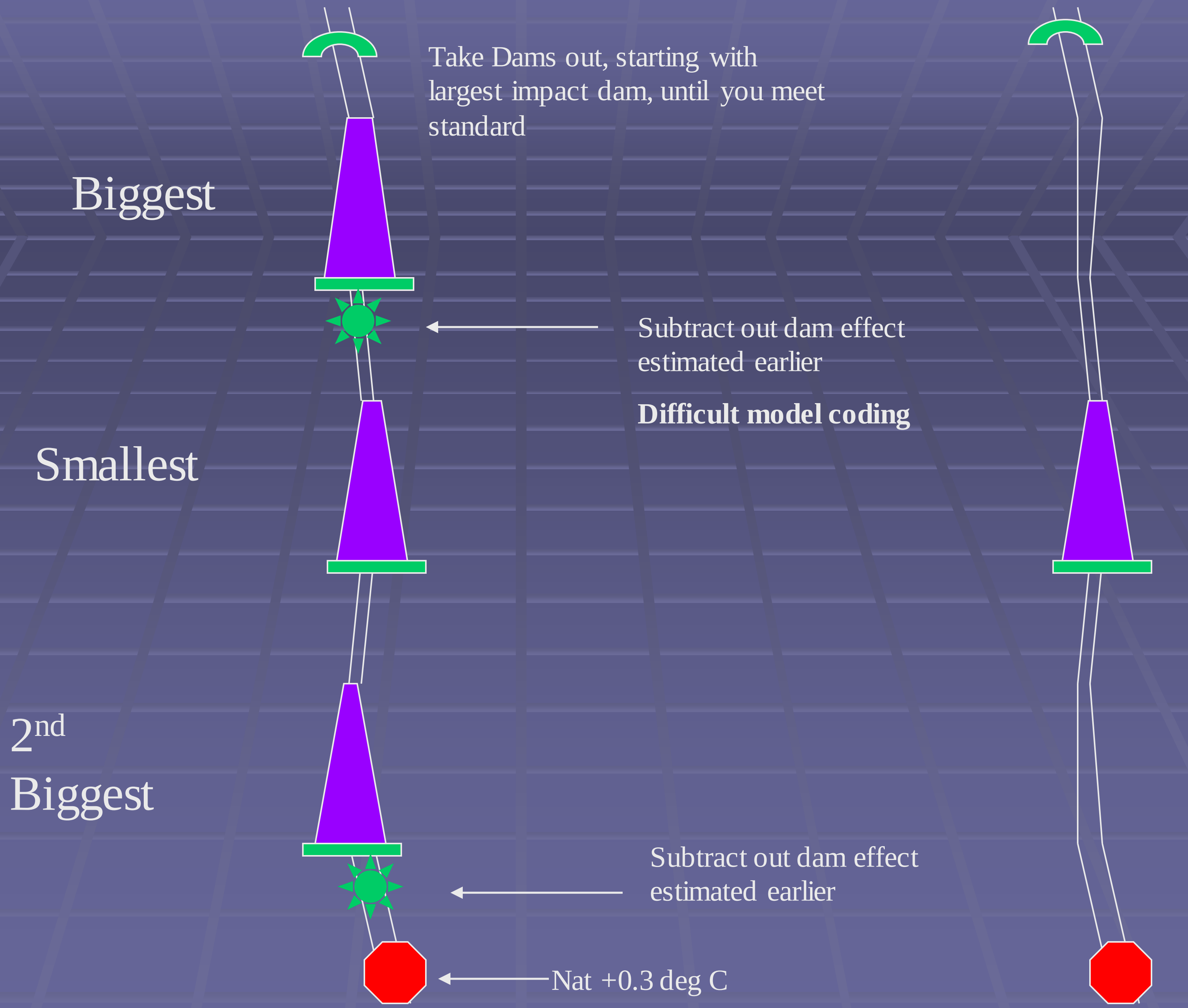
Month	Target Temp	Reduction
July	21.8	0.2
Aug	18.7	0.9
Sept	16.8	1.2

Load Allocations for **Dam 2**

Month	Target Temp	Reduction
July	22.3	0.2
Aug	19.2	0.4
Sept	17.3	0.4

Load Allocations for **Dam 3**

Month	Target Temp	Reduction
July	22.8	0.2
Aug	19.7	0.3
Sept	17.8	0.2


Take Dams out, starting with largest impact dam, until you meet standard
Biggest
Subtract out dam effect estimated earlier
Difficult model coding
Smallest
2nd Biggest
Subtract out dam effect estimated earlier
Nat +0.3 deg C

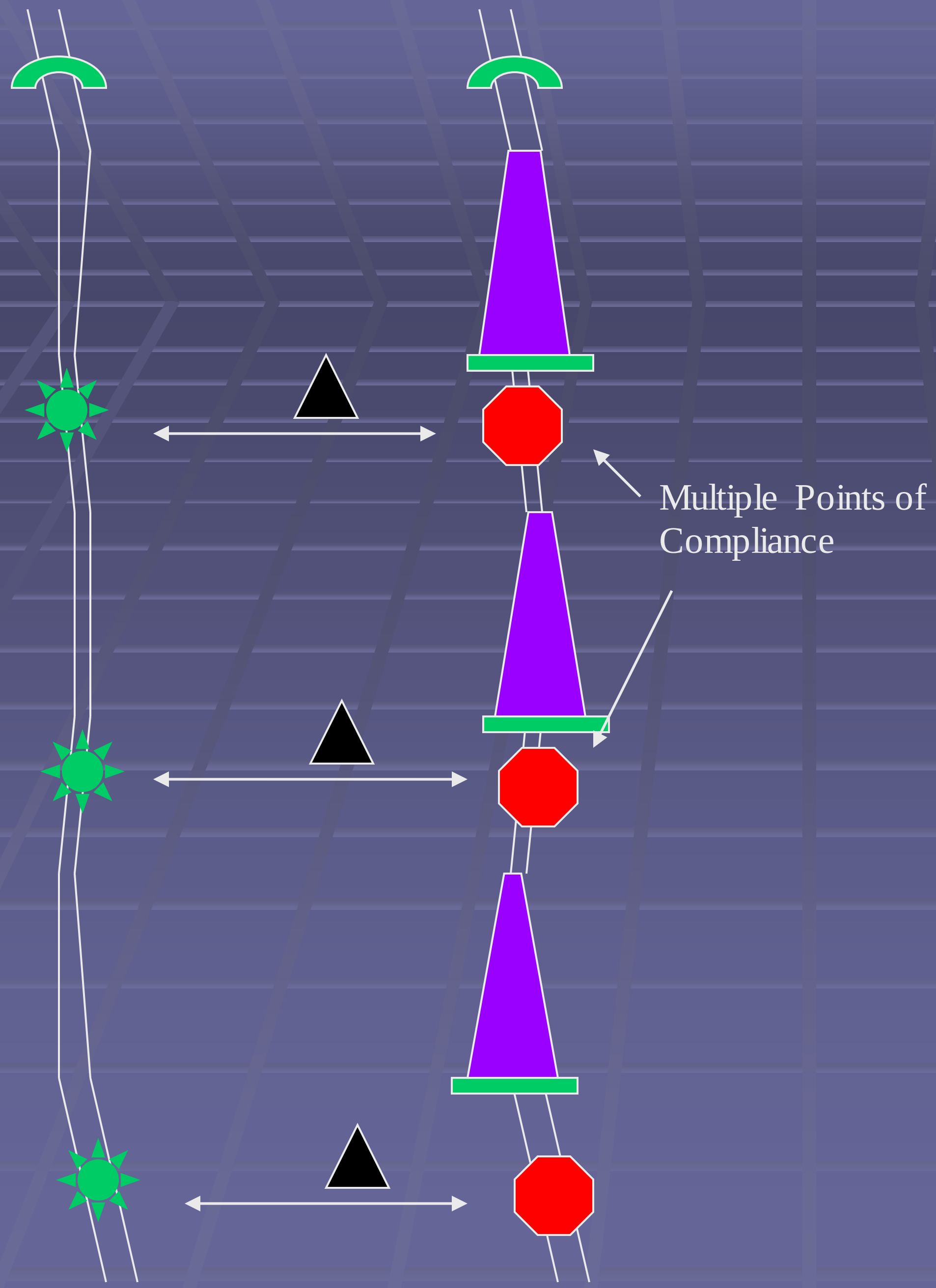
Individual Allocations Pros/Cons

- Pro
  - Can allocate existing impacts to small dams and get them off “the list”.
  - Individual dam responsibility

- Con
  - Very high analytical cost
  - Only a custom model can do it – bar too high
  - Hard to explain or implement resulting allocations
    - E.g., “Temperature reduction from what?”
      - from the simulated tailrace temperature with your dam in place but no upstream dams (?)

Reduce Complexity?

- Group allocations for dams
- No simulation of compliant condition
  - De-couple point source and dam allocations
    - Dams eliminate temperature shift – zero allocation
    - Point sources < 0.3 deg C impact



Load Allocations for **Dam 1**

Month	Target Temp	Current Condition	Temp Reduction
July	21.8	22.0	0.2
Aug	18.7	19.6	0.9
Sept	16.8	18.0	1.2

Load Allocations for **Dams 1 and 2**

Month	Target Temp	Current Condition	Temp Reduction
July	22.3	22.8	0.5
Aug	19.2	20.3	1.1
Sept	17.3	18.7	1.4

Load Allocations for **Dams 1, 2, and 3**

Month	Target Temp	Current Condition	Temp Reduction
July	22.8	23.5	0.7
Aug	19.7	21.1	1.5
Sept	17.8	19.5	1.8

Pros/Cons

- Pro
  - Low analysis cost
  - Easy to understand and explain
- Con
  - Group responsibility for dams, not individual
  - Small impact dams are included in group allocations